

Sliding friction study of the oscillating translational motion for steel on PA66 and PA46 type materials

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Abstract. The paper presents the study of the friction, by using tests, in the sliding translational oscillating motion of the steel on PA46 relative to the steel on PA66 type materials by considering as variables the testing parameters as: the load, the velocity and the operating temperature. The paper starts with a study of the literature and, according to that, presents the main conclusions regarding the sliding friction of the steel on PA66 and PA46 type materials and identifies the lacks of the results. The tests are performed on an oscillating motion type tribometer module. First, it is made a running-in program, for each of the materials, at 25 and 90°C, a load of 5 N and a frequency of 1 Hz for one hour; after that, there are performed tests at 90°C and 120°C, at loads of 3 N, 5 N, 7 N and at frequencies at 0.25 Hz, 0.5 Hz and 1 Hz. The results are presented for the PA46 type material relative to the PA66 material. The conclusions indicate in which conditions and with which advantages are used the PA66 and PA46 polyamides in the case of oscillating translational motions.

1. Introduction

The steel on PA66 and PA46 polyamides contacts have many applications in the case of sliding and rolling type frictions due to the small friction properties and small wear and deformations at high temperatures – food industry, automotive industry, mechanical transmissions used in open-air etc. At the beginnings of using the PA type materials, the PA66 was widely used due to its mechanical properties; in time, there were developed new PA type materials – as PA46 – with increased properties for friction and for their behaviour at different loads, velocities and temperatures. The literature presents many practical applications for each of these two materials (PA66 and PA46) depending on the working conditions.

The tests achieved in [1] shows that the PA46 polyamides have lower sliding friction with 20 – 30% than the PA66 polyamides; these tests have been performed at a temperature interval of 125 – 160°C for normal pressures between 0.5 and 5 MPa on a rotary module with high speeds – between 1000 and 4000 rpm.

Chiu and Kao are concluding in [2] that the PA46 polyamides are conserving their crystalline structure at high temperatures (up to 210°C) and due to that are conserving their mechanical properties more stable than PA66 [3].

The PA66 and PA46 polyamides in combination with steel with sliding friction are used mainly in automotive industry as materials for gears such as electric power steering (EPS), lifting mechanisms for the windows, adjusters for the seats, mechanisms for the sun roofs [4]. The tests performed in [4]



and [5] show that the PA46 polyamides have a better behaviour according to the development of the wear than the PA66 polyamides.

According to the study of the literature, the paper presents the experimental study of the sliding friction behaviour in the case of oscillatory translational motions of couples of materials – one made by steel and the other made by PA46 type material relative to the PA66 material – for different loadings, velocities and temperatures.

2. The equipments

The tests are performed on a UMT type tribometer [6] which allows the data acquisition to a computer as it can be seen in figure 1. The tribometer is equipped with a 2D force sensor with the range $F=10 \dots 1000$ N and the resolution $R_f=50$ mN. The vertical stroke is $d=150$ mm with the speed of $v_v=0.001 \dots 10$ mm/s. The lateral positioning stroke is $l=75$ mm with the speed of $v_l=0.01 \dots 10$ mm/s; the lateral positioning resolution is $R_r=2$ μm . The accuracy of the wear measurements is $R_r=50$ nm. The temperature can be controlled in the oil bath up to $t=150^\circ\text{C}$.

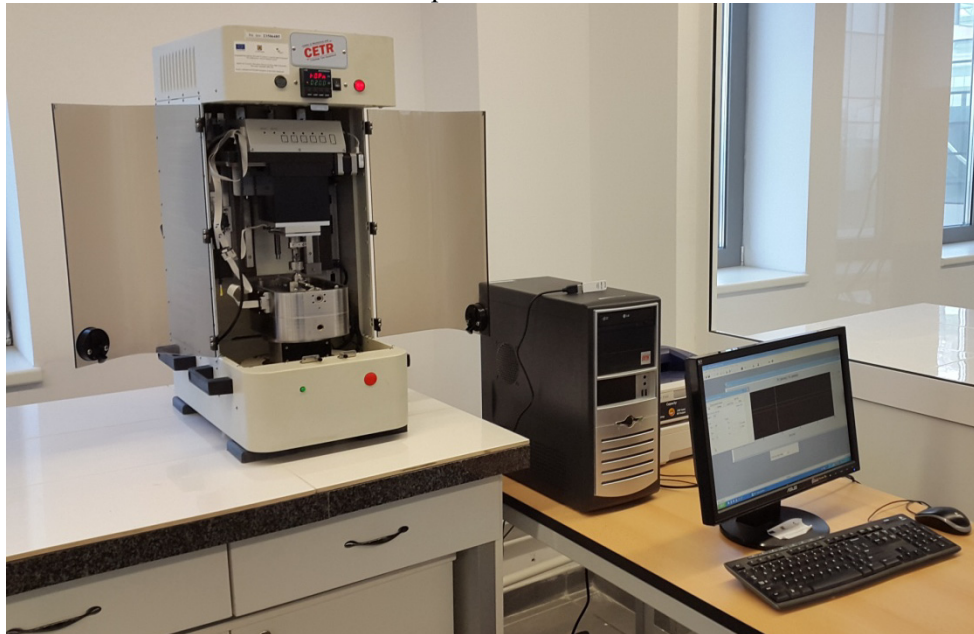


Figure 1. The tribometer.

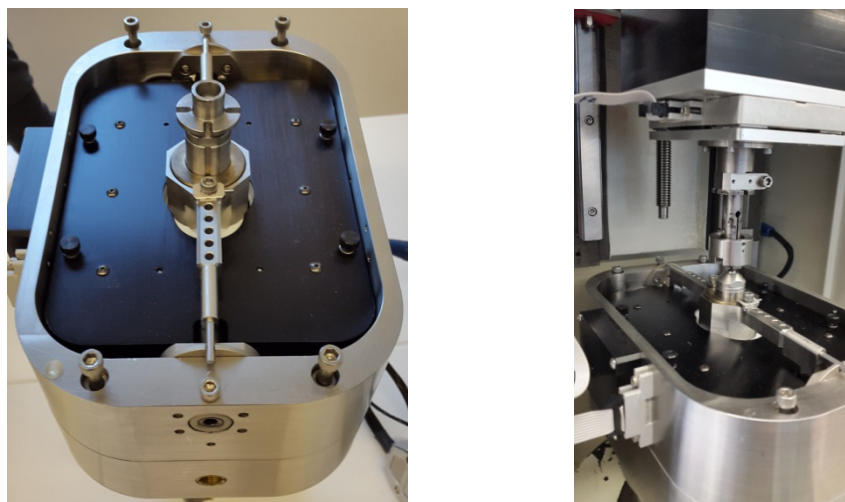


Figure 2. The reciprocating module.

The translational oscillatory motions are achieved on the reciprocating module which is one of the tribometer's components [6]. On the reciprocating module – figure 2 – there may perform tests for point, line and area type contacts between couple of materials as metallic on metallic, metallic on plastic or plastic on plastic. The module is equipped with a force transducer which allows to measure loads up to $F=1000$ N with a resolution of $R_f=1$ μ N. The stroke of the reciprocating module can be controlled in an interval as $s=0.05 - 25$ mm with a frequency of the motions as $\nu=0.1 - 60$ Hz.

3. The tests

The tests are performed for the contact between a steel plate and a PA66 and a PA46 polyamides. The steel plate is mounted in a holder which is acting with a normal load on the plastic materials which are mounted in the reciprocating module – figure 3.

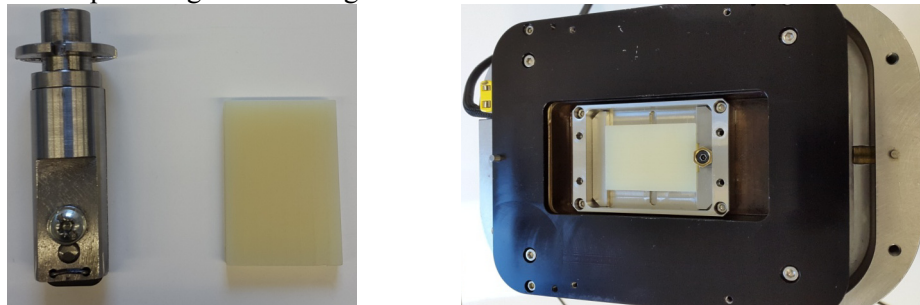


Figure 3. The mounting of the steel plate and the plastic material.

Before the tests it is made a running-in program, for each of the materials, for two temperatures – at 25 and 90°C, a load of 5 N and a frequency of 1 Hz for one hour in order to stabilize the value of the friction coefficient; during the running-in program the system is measuring the friction coefficient and the wear.

The tests are achieved at 90°C and 120°C, at loads of 3 N, 5 N, 7 N and at frequencies at 0.25 Hz, 0.5 Hz and 1 Hz; during the tests the system is measuring the friction coefficient.

The results are given as relative values of the PA46 to the PA66 due to confidential reasons imposed by the producing company.

4. Results and conclusions

Due to confidentiality reasons, the percentage difference of the wear for the PA46 material relative to the PA66 is presented in figure 4, depending on the two temperatures used in the running-in process.

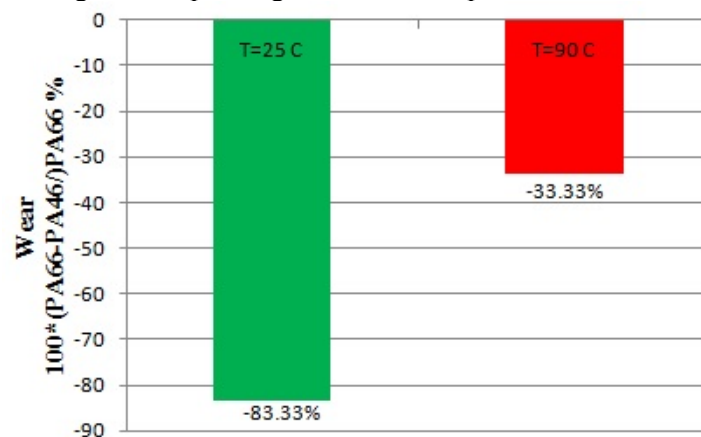


Figure 4. The wear percentage difference of PA46 relative to PA66 material.

After the running-in process at a temperature of 25⁰C, the PA46 material has a smaller wear with 83.33% than the PA66 material; for a running-in process at 90⁰C, the wear for the PA46 material is smaller with 33.33% than the wear for the PA66 material.

Due to confidentiality reasons, the variation of the percentage difference for the friction coefficient of the PA46 material relative to PA66, depending on the normal load, is presented in figure 5, for two temperatures used during the tests (90⁰C and 120⁰C).

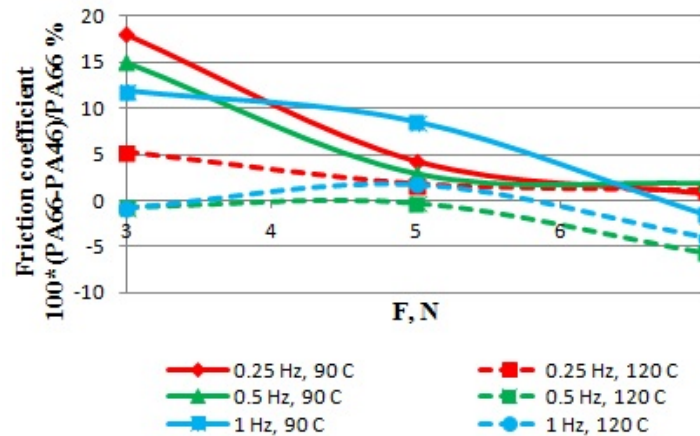


Figure 5. The variation of the percentage difference for the friction coefficient of PA46 relative to PA66 material with the normal load.

According to the results, the friction coefficient is decreasing with the increasing of the normal load; smaller relative friction coefficients of PA46 to PA66 are obtained for high temperature (120⁰C) in the case of high loads (for instance for a loads of 7 N which is equivalent to a local pressure of 0.36 MPa the friction coefficient at 120⁰C can be with 5% smaller for the PA46 type material than the case of the PA66 type material).

Due to confidentiality reasons, the variation of the percentage difference for the friction coefficient of the PA46 material relative to PA66, depending on the motion frequency, is presented in figure 6, for two temperatures used during the tests (90⁰C and 120⁰C).

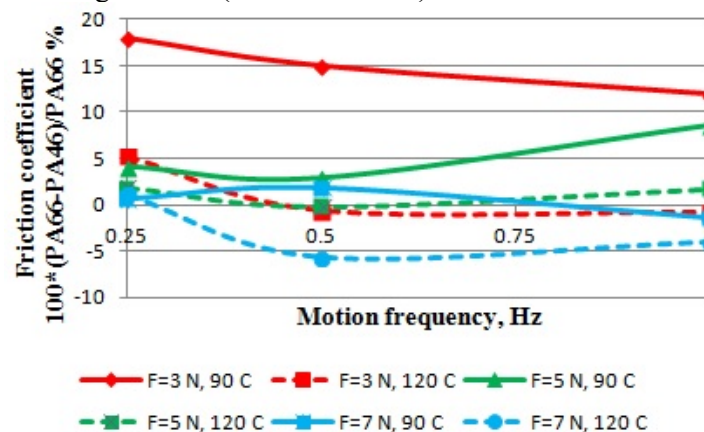


Figure 6. The variation of the percentage difference for the friction coefficient of PA46 relative to PA66 material with the motion frequency.

According to the results, the friction coefficient is decreasing with the increasing of the motion frequency; smaller relative friction coefficients of PA46 to PA66 are obtained for high temperature (120⁰C) in the case of high frequencies of the motion (for instance for frequencies bigger than 0.5 Hz

which is equivalent to speeds bigger than 2.33 mm/s, the friction coefficient at 120°C can be with 5% smaller for the PA46 type material than the case of the PA66 type material).

Due to confidentiality reasons, the variation of the percentage difference for the friction coefficient of the tested materials, for the temperature of 120°C relative to the temperature of 90°C, depending on the motion frequency, is presented in figure 7, for the normal loads of 3 N, 5 N and 7 N.

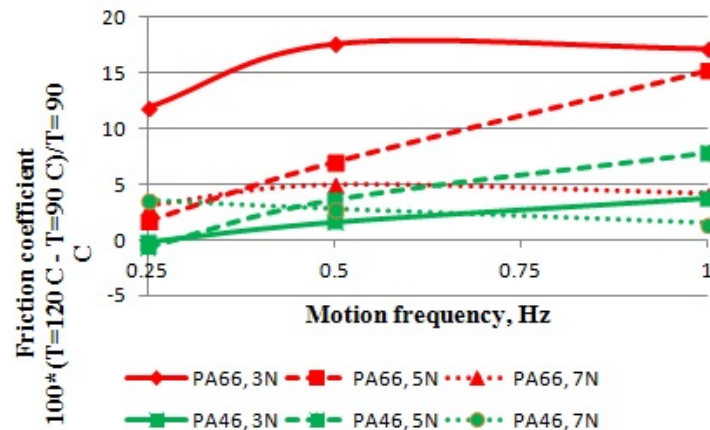


Figure 7. The variation of the percentage difference for the friction coefficient, for the temperature of 120 °C relative to the temperature of 90 °C.

For the same applied normal load, the PA46 type material has a smaller increase of the friction coefficient (the maximum increase is with 7.8%) than the PA66 type material (the maximum increase is 17.5%) and that increasing is more stabilised with the increasing of the motion's frequency.

As general conclusion, the PA46 type material has a more stabile behaviour of the friction coefficient in combination with steel plates when it is used for oscillatory translational motions than the PA66 type material; the values of the friction coefficient for steel/PA46 contacts are smaller in the case of high temperatures (120°C), high loads (equivalent for local pressures bigger than 0.36 MPa and high speeds (bigger than 2.33 mm/s); the wear during the running-in process is also smaller for the PA46 type material instead of the PA66 type material.

5. References

- [1] Van Ruiten J, Proost R and Meuwissen M 2012 How the choice of the polyamide type in timing chains tensioning systems affects the CO₂ emission and fuel economy of internal combustion engines *Presentation at VDI Veertiltrieb und Zylinderkopf 2012*
- [2] Chiu F-G and Kao G-F 2012 Polyamide 46/multi-walled carbon nanotube nanocomposites with enhanced thermal, electrical and mechanical properties *Composites* **43** pp 208 – 218
- [3] Chiu F-G, Fu S W, Chuang W T and Sheu H S 2008 Fabrication and characterization of polyamide 6.6/organomontmorillonite nanocomposites with and without a maleated polyolefin elastomer as a toughener *Polymer* **49** pp 1015 – 1026
- [4] Wilson B S 2012 *Traction and wear evaluation of a number of plastic materials and greases under combined rolling and sliding contact conditions*, Master Degree Thesis (USA: The Ohio State University)
- [5] Gordon D H and Kukureka S N 2009 The wear and friction of polyamide 46 and polyamide 46/aramid-fibre composites in sliding-rolling contact *Wear* pp 669-678
- [6] *** UMT Multi-Specimen Test System. Hardware Installation & Application Manual 2009 *Center for Tribology, Dell Ave, Campbell, USA*